Conceptual design of the retroreflector, photodetector, and optical beacon payloads for the Photon target satellite

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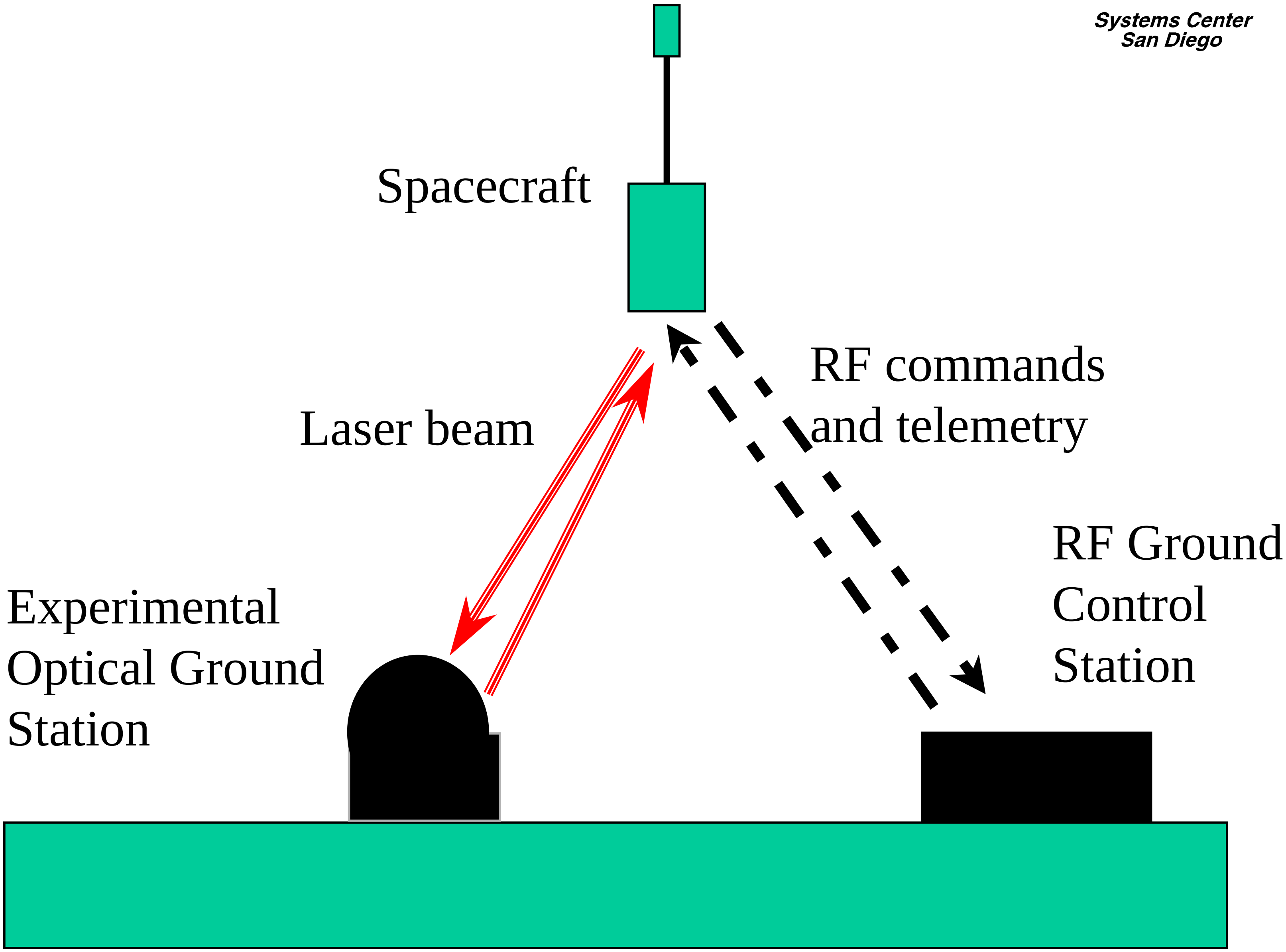
* Funded by the Ballistic Missile Defense Organization, through the Space and Naval Warfare Systems Center San Diego, under contract # N66001-97-C-8644.

Retroreflectors in space

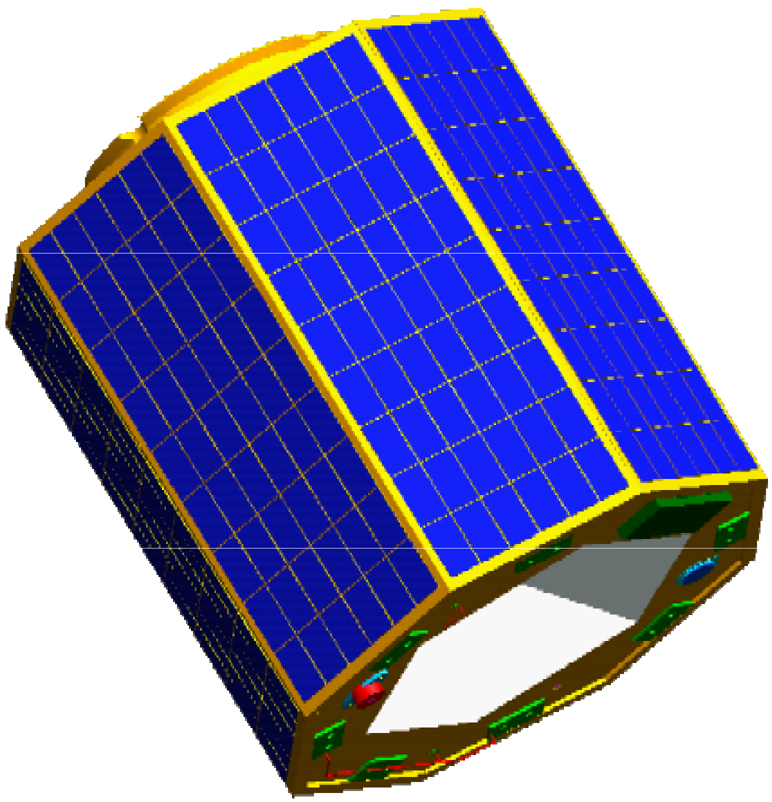
- Used for experiments in:
  - differential absorption lidar (DIAL)
  - atmospheric propagation
  - orbital tracking
  - laser radar
  - optical communications
  - etceteras …
- Usually carried as secondary payloads
  - exceptions include LAGEOS, RIS

Mission Concept

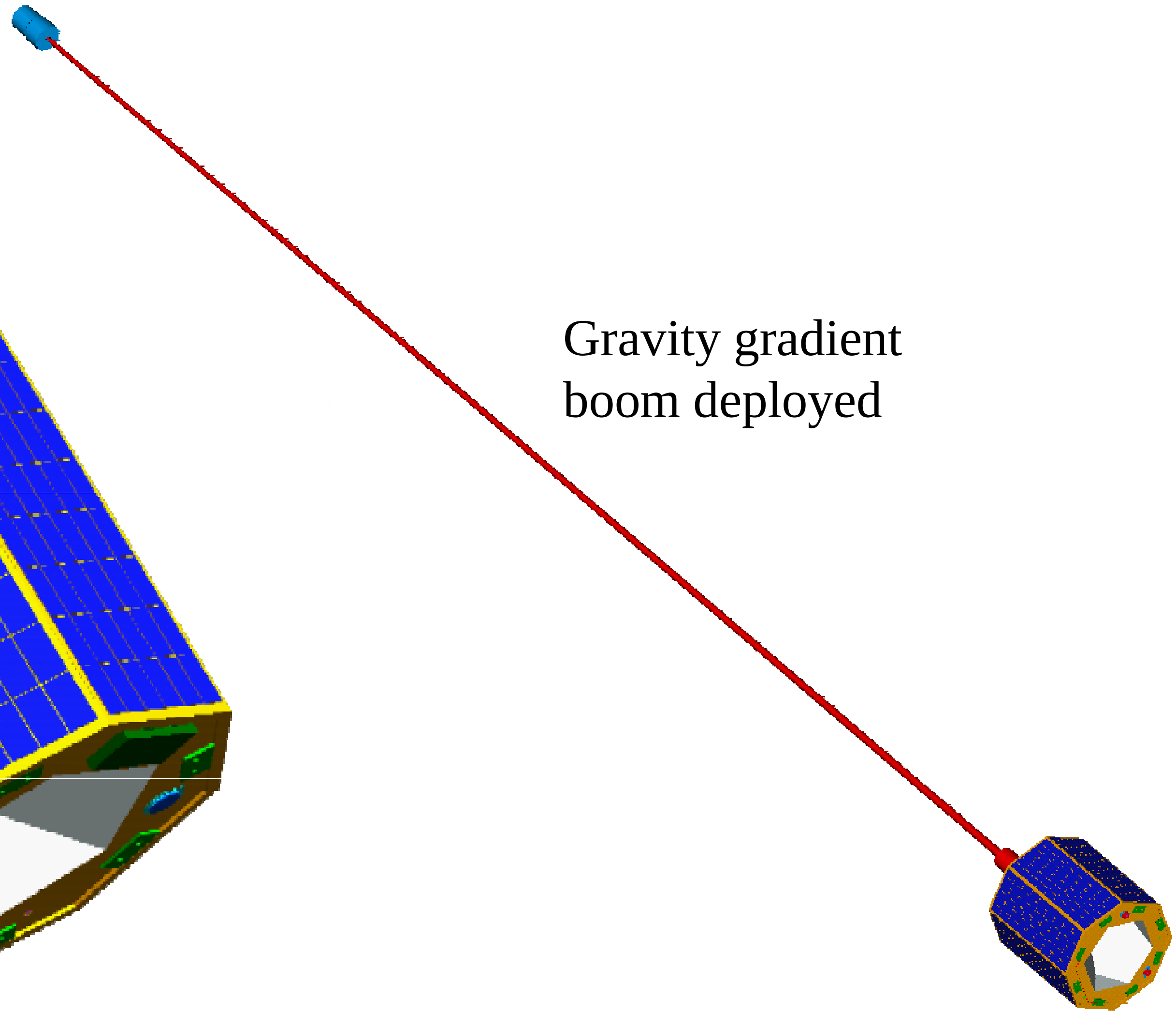


Photon Spacecraft

Gravity gradient boom stowed



Gravity gradient boom deployed



Primary Payloads

- Photon is a dedicated optical target spacecraft, carrying three payloads:
  - large (27 cm diameter) single retroreflector
  - optical beacon
  - photodetector

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Photon Advantages

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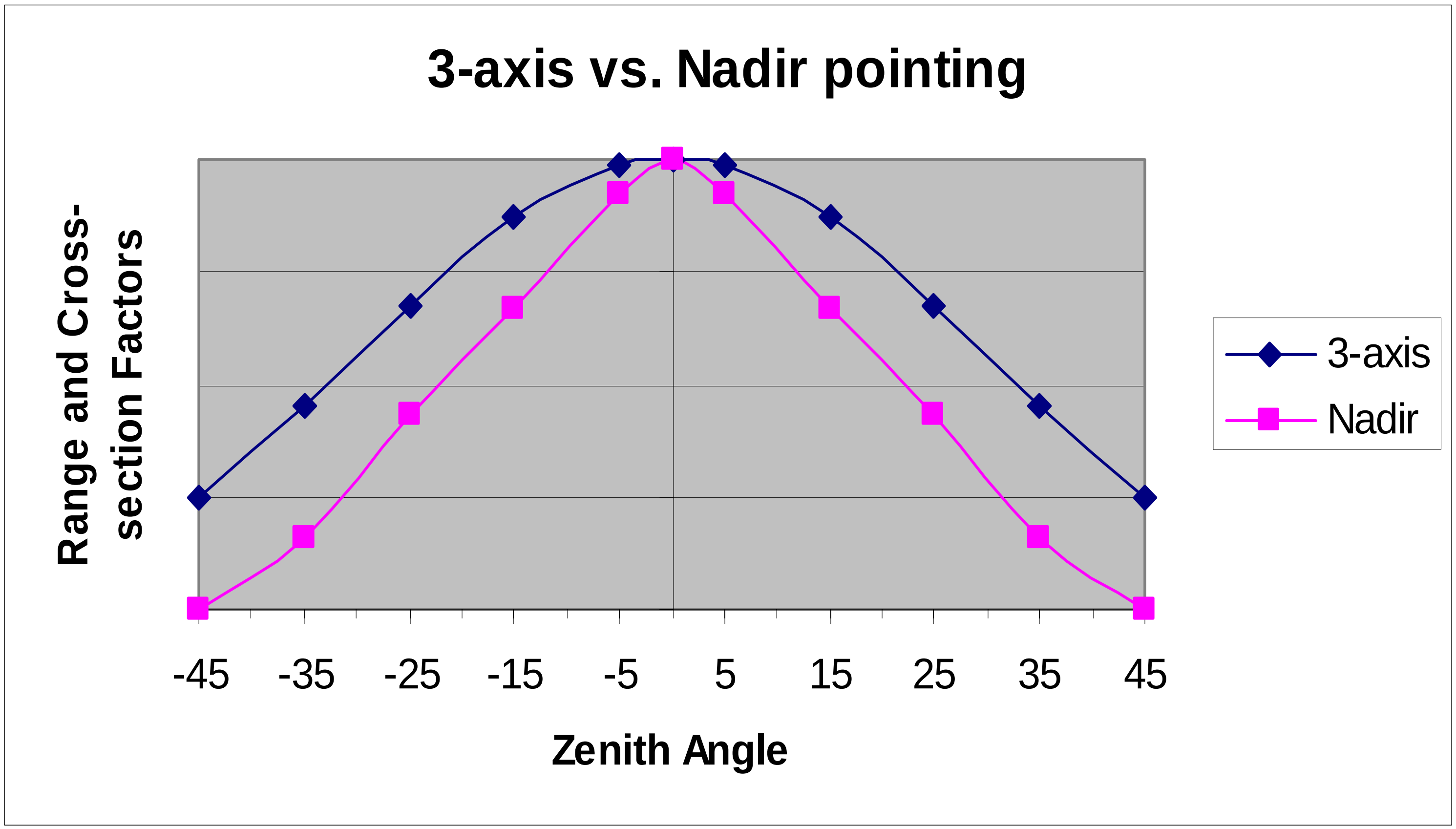
- Retroreflector:
  - complex/expensive equipment is located on the ground
  - accommodates a wide range of possible experiments
  - *single* retroreflector avoids interference effects exhibited by arrays
  - effective cross-section will exceed that of any others currently in orbit (or known to be in development)
- Photodetector:
  - provides independent data for the uplink path
- Optical beacon:
  - facilitates acquisition
  - provides independent information on the downlink path

Comparison of spaceborne retroreflectors

Satellite	Minimum Range [km]	Effective Diameter [cm]	Figure of Merit D^2/R^4 [1/m^2]	Number of Retro's	Beacon	Detector	Notes
LAGEOS-1,-2	5860	24	2 E-28	426	NO	NO	
ADEOS	797	50	1 E-24	1	NO	NO	(failed)
AJSAT	1490	215	4 E-25	1436	NO	NO	
STARLETTE	812	24	6 E-25	60	NO	NO	
STELLA	800	24	6 E-25	60	NO	NO	
ERS-1,-2	780	18	5 E-25	9	NO	NO	
TOPEX/POSEIDON	1340	150	5 E-25	192	NO	NO	
METEOR-3	1180	28	1 E-25	24	NO	NO	
GFZ-1	396	20	8 E-24	60	NO	NO	
TIPS	1022	?	?	18	NO	NO	
GPS-35,-36	20200	24	1 E-30	?	NO	NO	
ETALON-1	19120	129	1 E-29	2134	NO	NO	
GLONASS	19140	120	9 E-30	396	NO	NO	
FIZEAU	931	15	2 E-25	3	NO	NO	
RESURS-01	678	15	7 E-25	1	NO	NO	
MSTI-II	431	18	5 E-24	9	NO	NO	
BE-C	940	?	?	? (multi)	NO	NO	
PHOTON	350	27	**1.8 E-23**	**1**	**YES**	**YES**	(planned)

Attitude control trade study

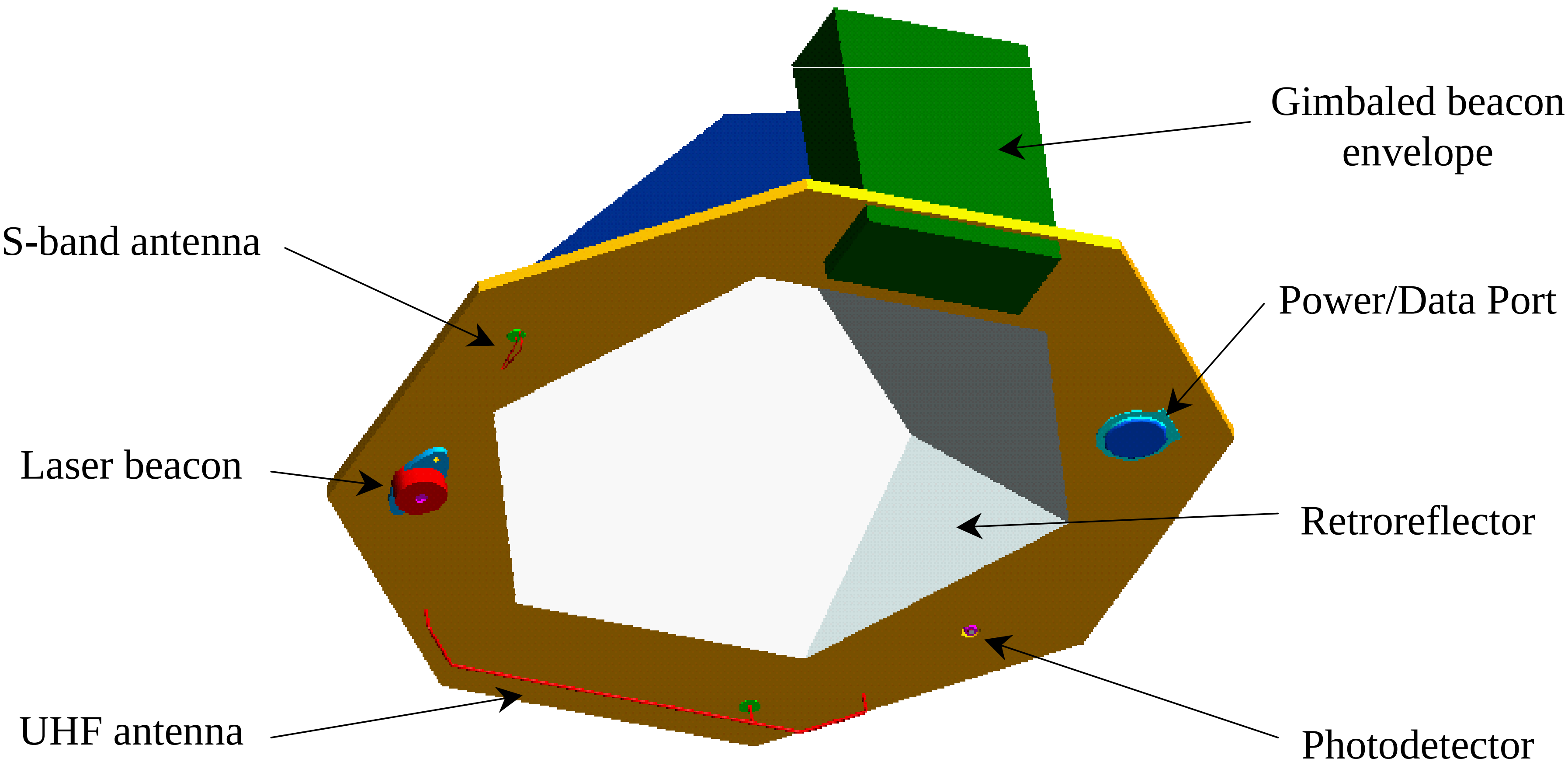


Predicted number of passes with elev.>60º

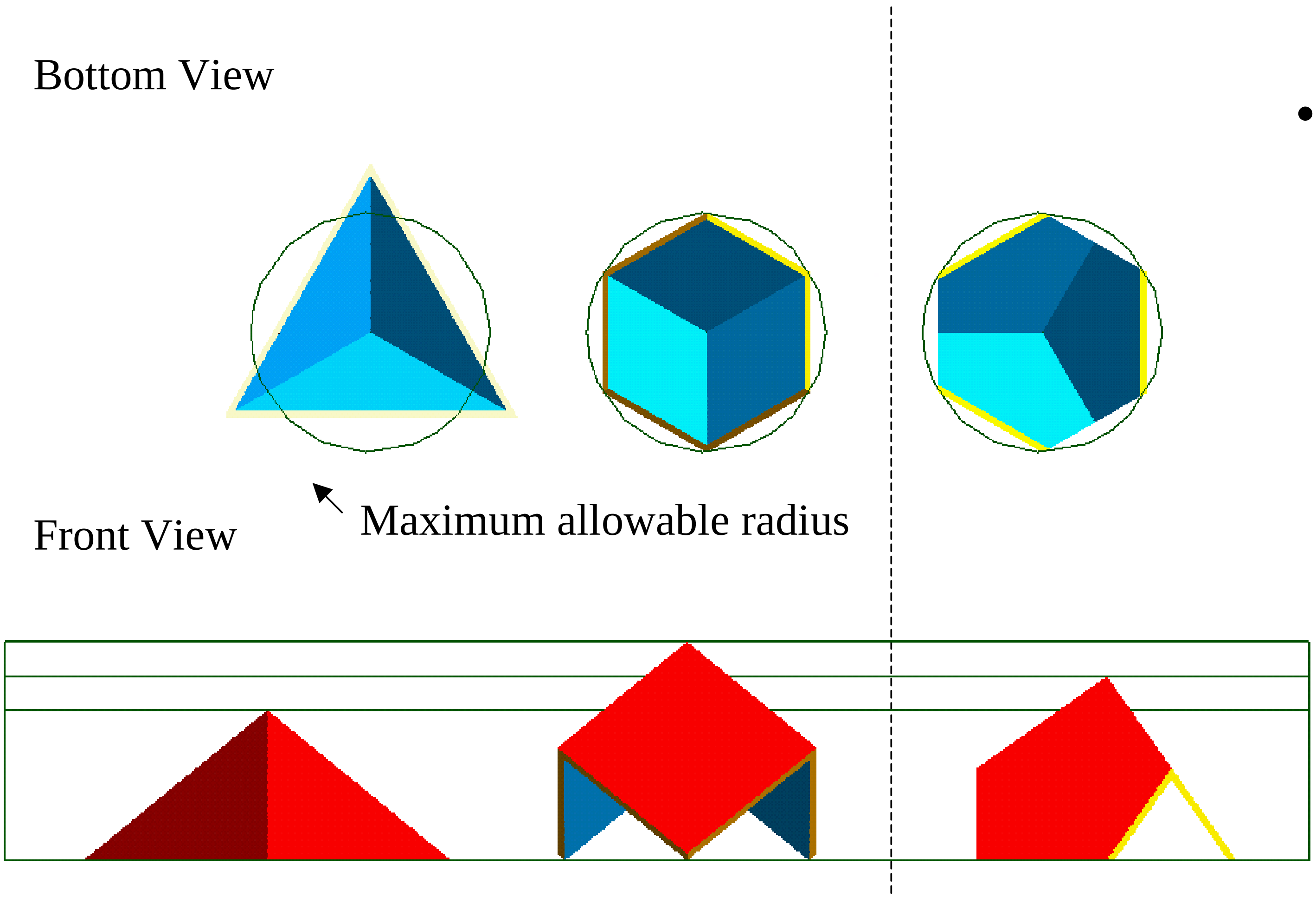
Orbit	Columbia	Space Station
Nominal Lifetime [days]	162	474
95% Prob. Lifetime [days]	85	241
Passes/year	706	177
Nominal Passes	**313**	**230**
95% Prob. Passes	164	117

- lifetimes based on 1/1/2001 launch date
- for ground station at 28.5º latitude

Payload Module



Retroreflector Design

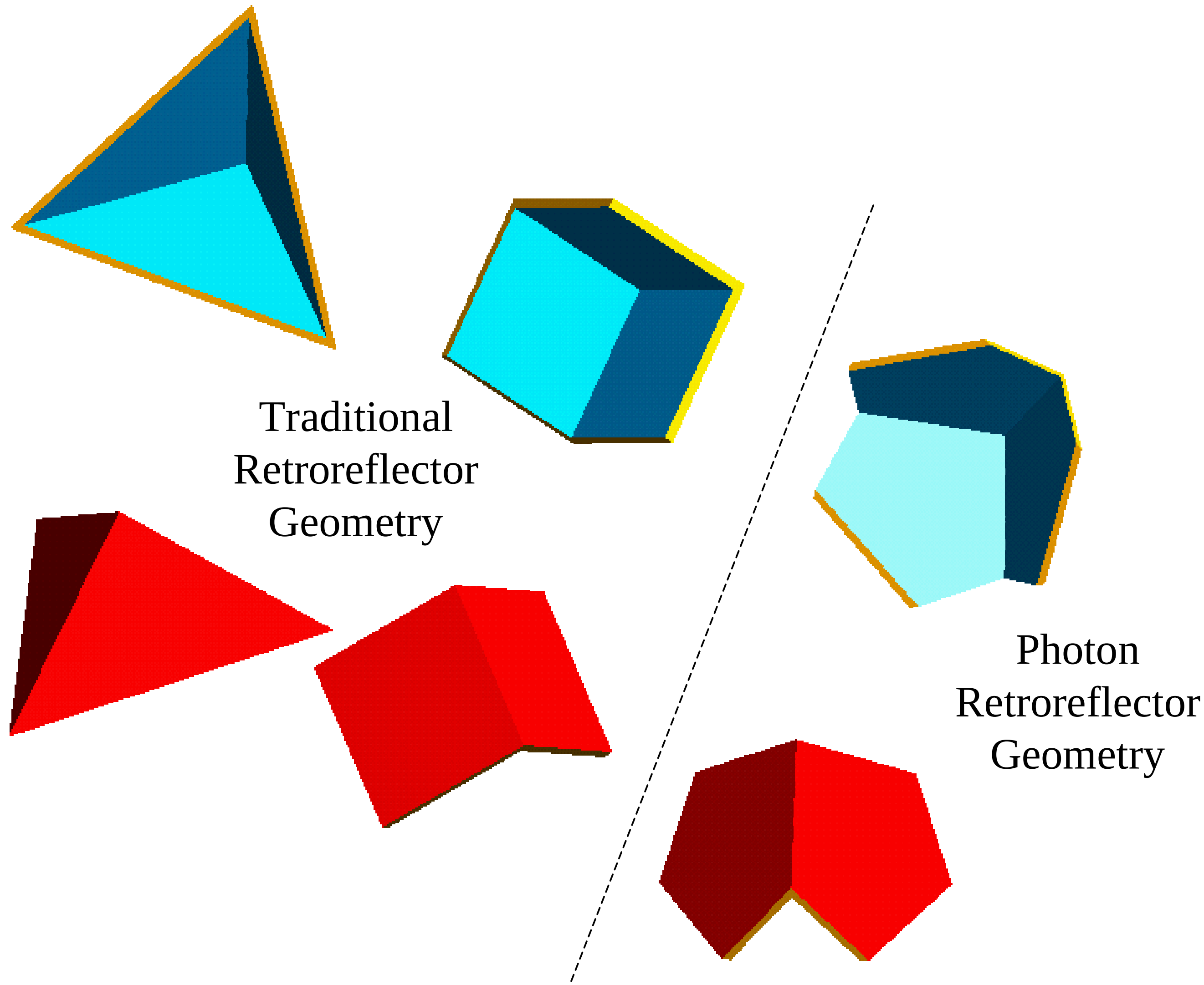


- Photon Retroreflector
  - Maximized cross sectional area
  - Minimized height

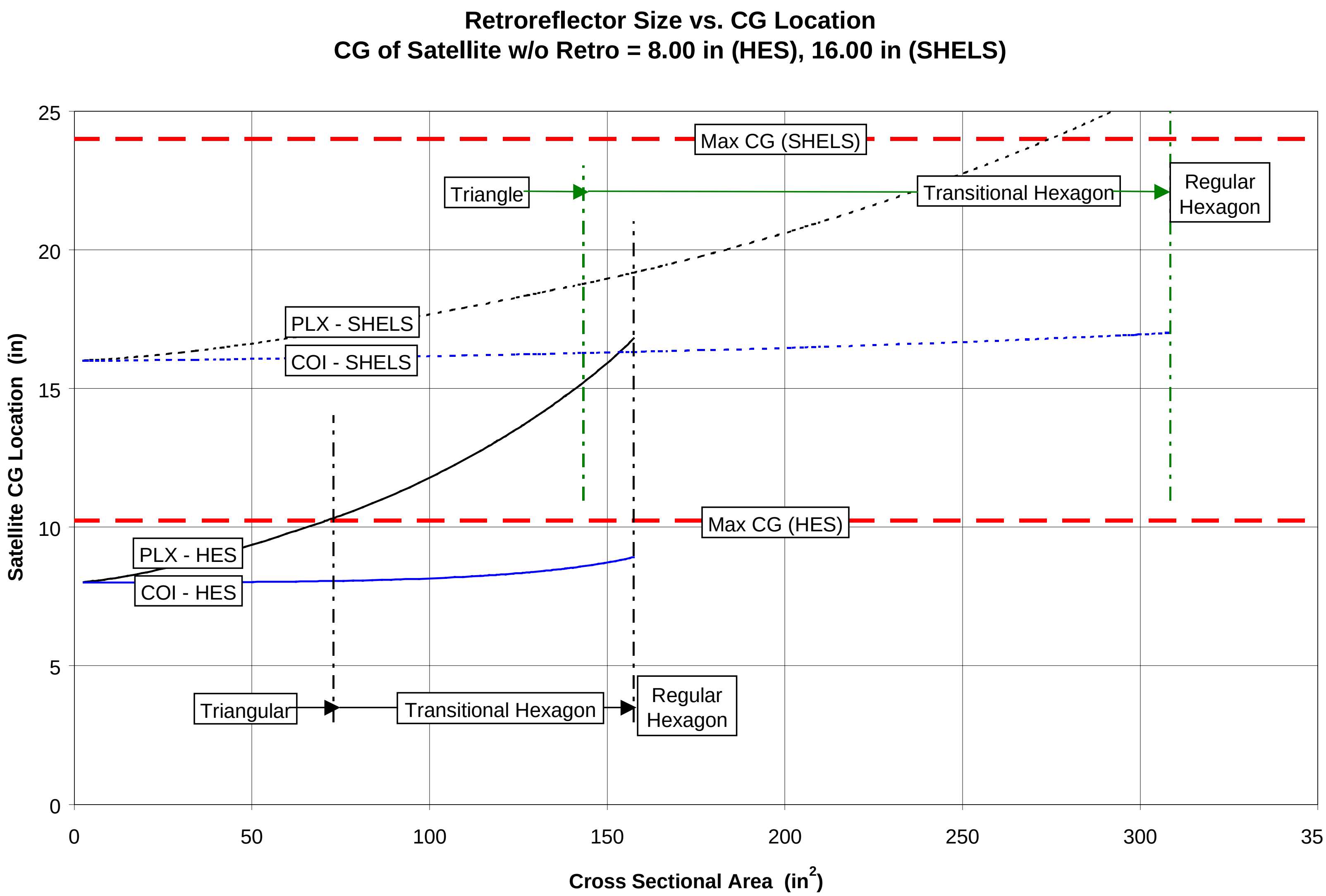
Retroreflector Design

Isometric
Bottom View

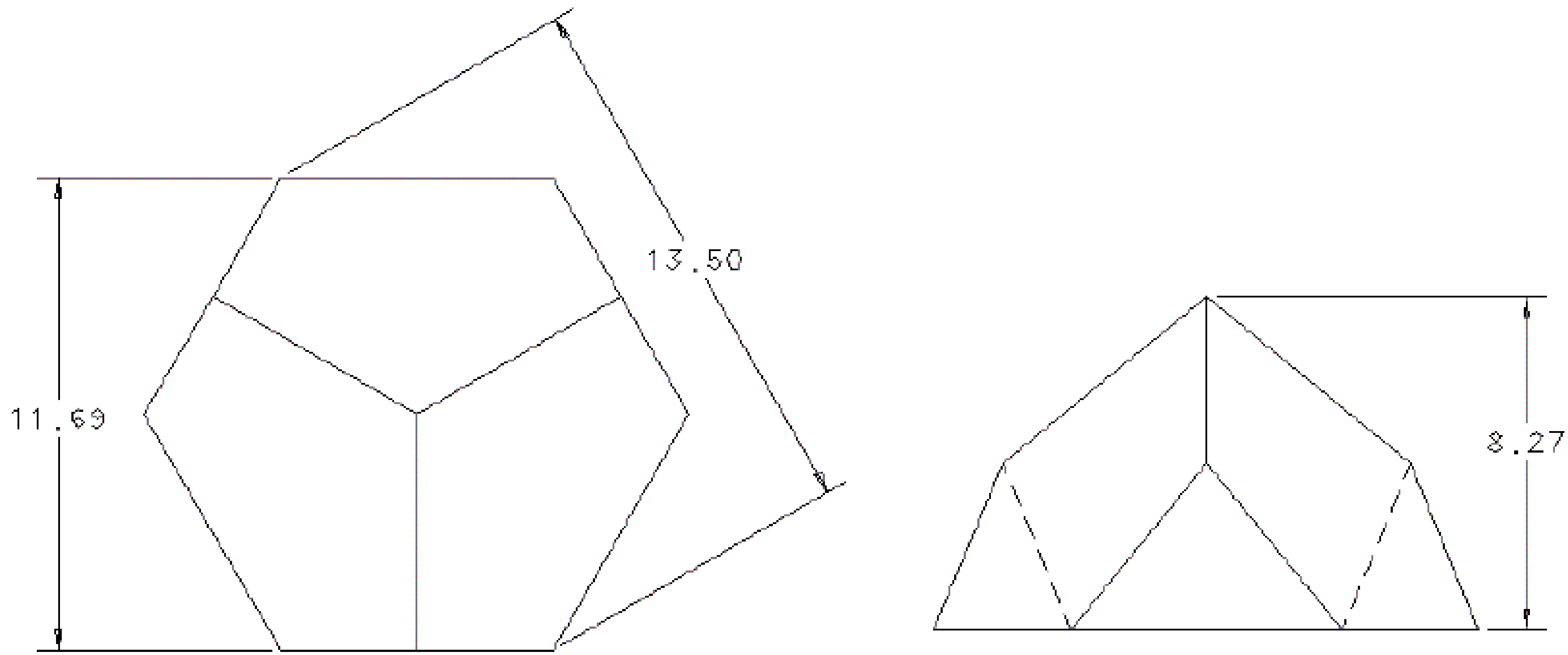
Isometric
Top View



Retroreflector size constraints

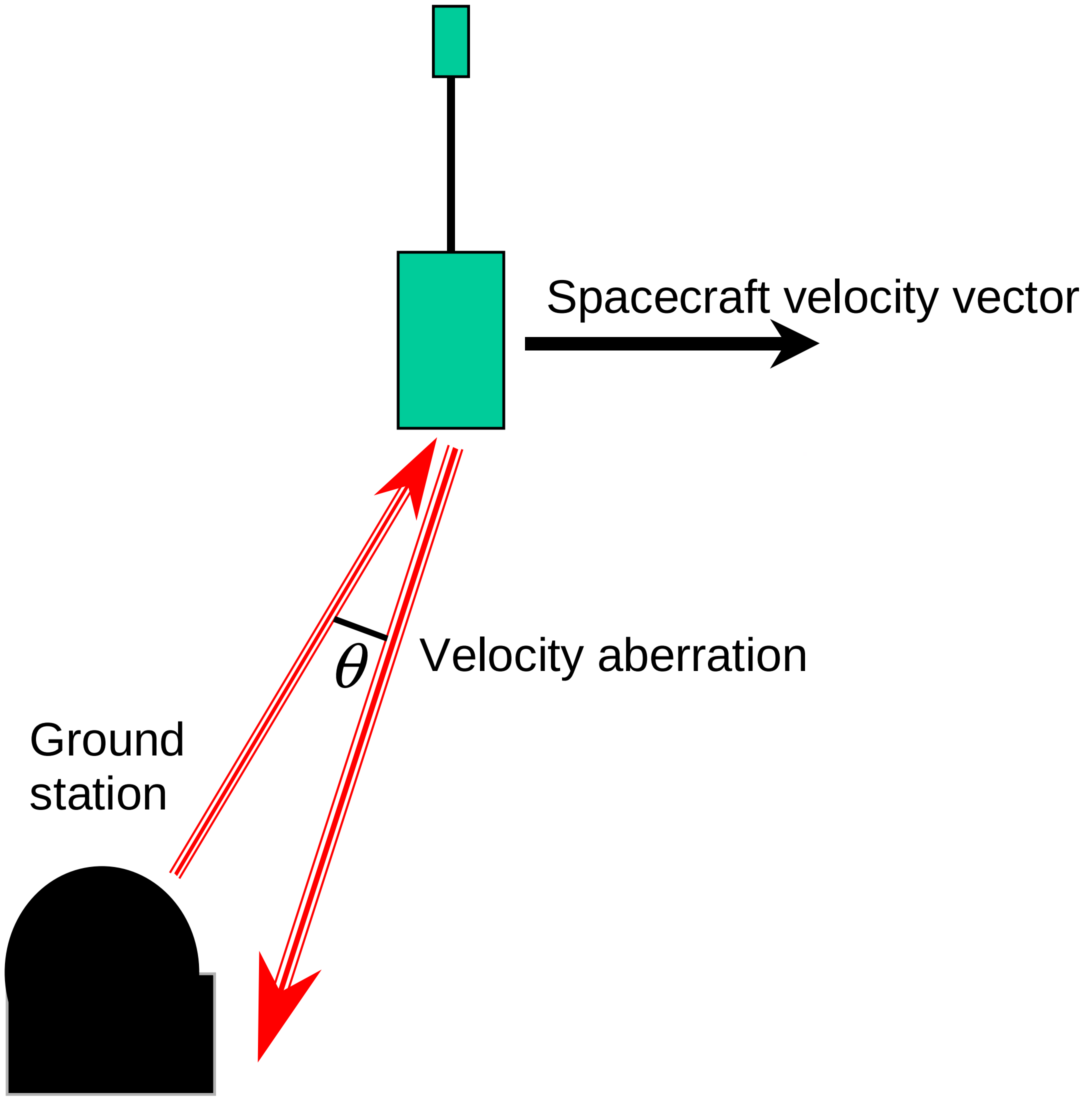


Retroreflector envelope



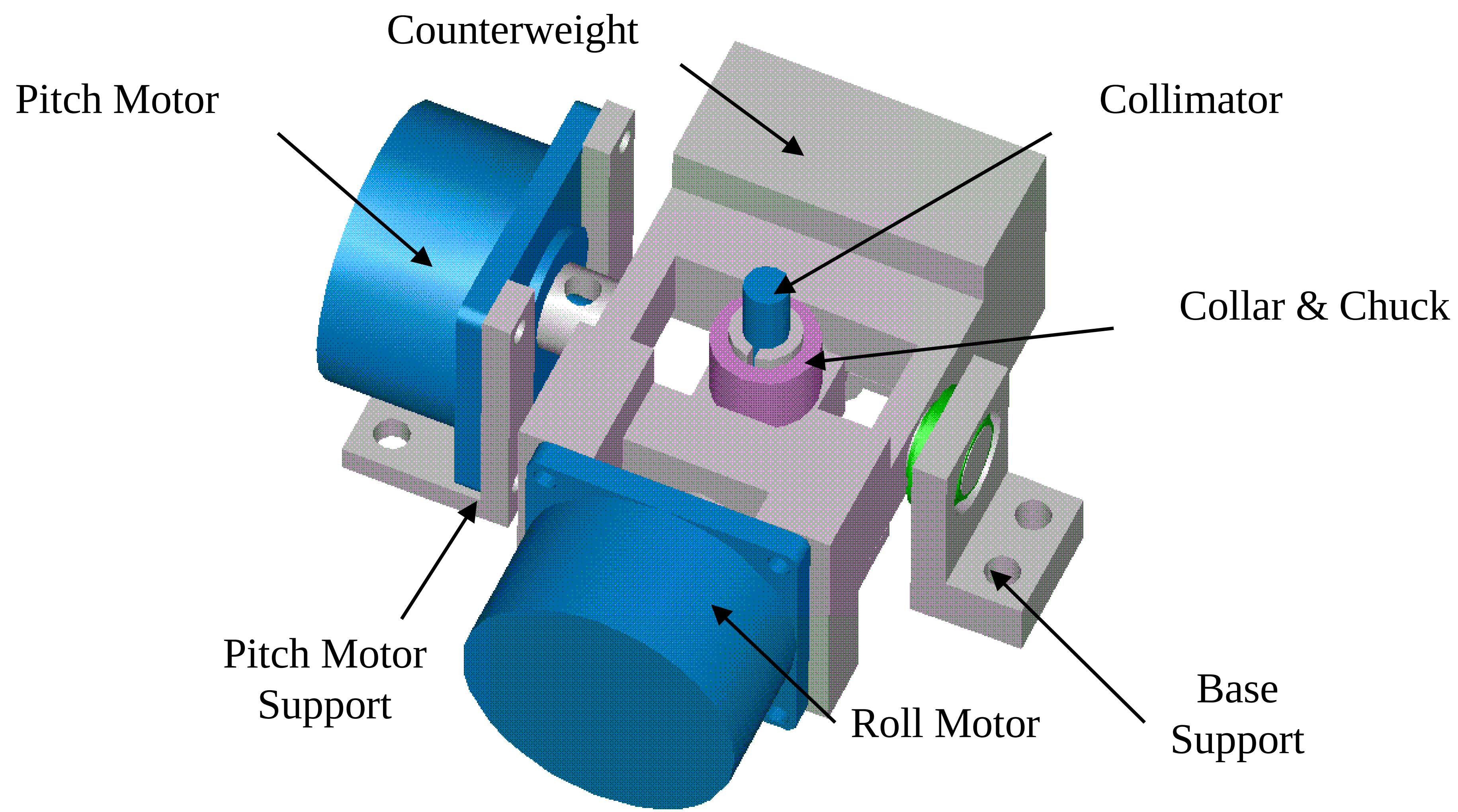
- Maximum dimensions of retroreflector assembly (mirrors and supporting structure)

Velocity Aberration

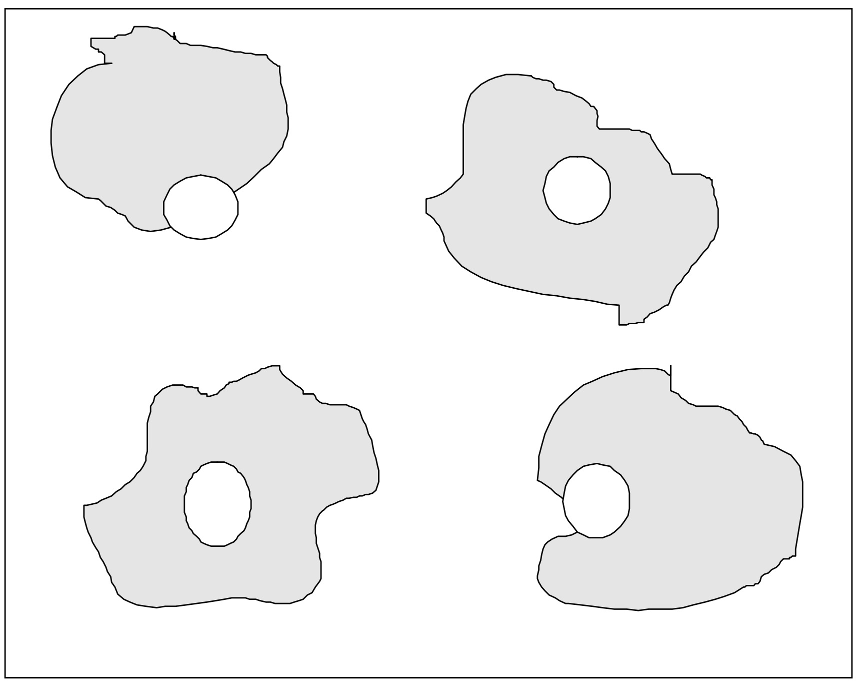


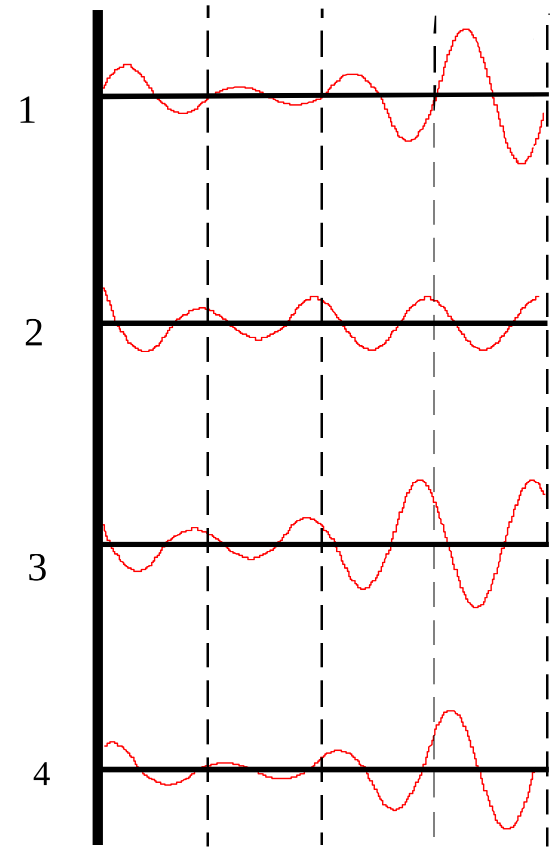
$$\theta = \frac{2v\sin\phi}{c}$$

Gimbaled Beacon



Co-phased array experiment





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Eight-element co-phased array receiver

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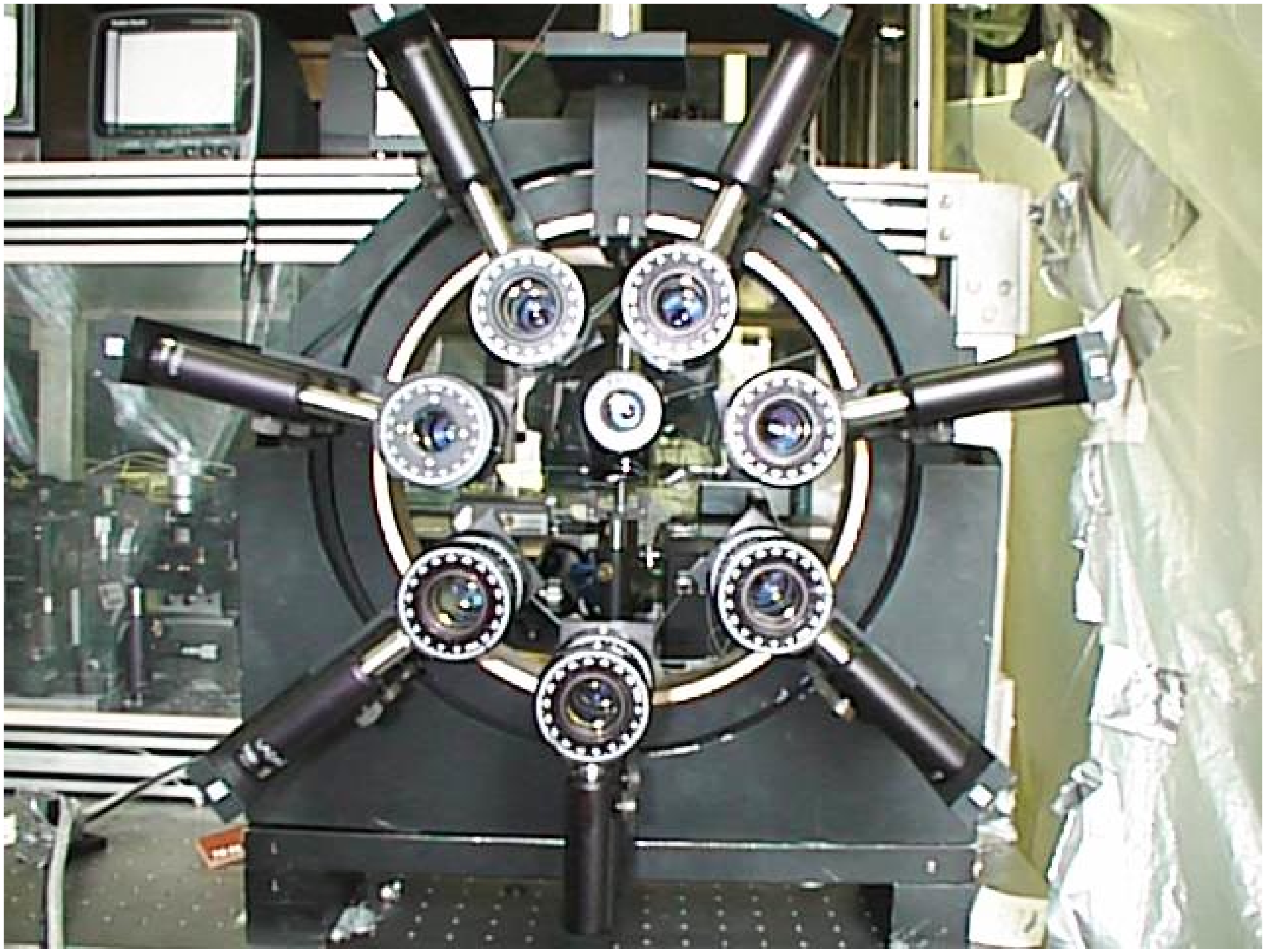

Additional experiments invited

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